

CLAIMS

What is claimed is:

1. A measurement method for detecting mass based on a change in vibration frequency of a piezoelectric vibration reed for mass measurement, the measurement method comprising:

a step of supplying an excitation signal to excite the piezoelectric vibration reed and calculating a phase difference between an output signal of the piezoelectric vibration reed and the excitation signal; and

a step of adjusting the frequency of the excitation signal corresponding to the phase difference and calculating the vibration frequency of the piezoelectric vibration reed by.

2. A circuit for exciting a piezoelectric vibration reed for mass measurement, comprising:

a voltage controlled oscillator for supplying an excitation signal to the piezoelectric vibration reed for mass measurement;

a phase detection unit for calculating a phase difference between the excitation signal from the voltage controlled oscillator and an output signal from the piezoelectric vibration reed; and

a control voltage output unit for supplying a voltage corresponding to the phase difference calculated by the phase detection unit to the voltage controlled oscillator, and allowing the excitation signal having the same frequency as the frequency of the output signal of the piezoelectric vibration reed to be outputted to the voltage controlled oscillator.

3. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 2, wherein the piezoelectric vibration reed is connected to a coil in parallel or in series.

4. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 2, wherein a phase shifter for controlling a phase delay or advance of the excitation signal is provided between the voltage

controlled oscillator and the phase detection unit.

5. A circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 4, wherein a multiplier is provided at an output side of the voltage controlled oscillator, and the excitation signal is supplied to the piezoelectric vibration reed and the phase detection unit through the multiplier.

6. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 5, wherein dividers are provided between the piezoelectric vibration reed and the phase detection unit and between the multiplier and the phase detection unit.

7. A circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 6, wherein the phase detection unit and the control voltage output unit are made with digital

circuits.

8. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 7, wherein a charge pump is provided between the phase detection unit and the control voltage output unit.

9. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 7, wherein the control voltage output unit has a digital signal processor.

10. A circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 9, wherein a plurality of the piezoelectric vibration reeds are provided, a switch unit is provided between the piezoelectric vibration reeds and the voltage controlled oscillator to supply the excitation signal by sequentially switching the piezoelectric vibration reeds, or switch units are provided between the piezoelectric vibration reeds

and the voltage controlled oscillator and between the piezoelectric vibration reeds and the phase detection unit.

11. A circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 10, wherein the piezoelectric vibration reed is for measurement in liquid, which has a sensitive film only on one side surface thereof.

12. A circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 10, wherein the piezoelectric vibration reed is for measurement in air, which has a sensitive film on both side surfaces or on one surface thereof.

13. A circuit for exciting a piezoelectric vibration reed for mass measurement according to Claim 2, wherein a variable gain amplifier is provided between the voltage controlled oscillator and the piezoelectric

vibration reed and uniformly controls an input voltage to a phase comparator.

14. A mass measurement apparatus including a circuit for exciting a piezoelectric vibration reed for mass measurement according to any one of Claims 2 to 13.